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CHANGE IN THE PROPERTIES OF GLASS UNDER THE EFFECT OF IONIZING RADIATION

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The possibility of improvement of the physicochemical and technical properties of glass products under the effect of ionizing radiation is demonstrated. Radiation treatment increases the homogeneity of the glass mixture (accelerates silicate-forming and glass-forming processes) and mechanical strength of technical glass and improves its service properties.

Glass belongs to the solid substances which exist in the amorphous state and are produced by supercooling of a melt. Any inclusions in the material change its isotropy, which is the most important factor for the high quality of the glass, and produce changes in the physicochemical and mechanical properties of the glass, which is manifested clearly under the effect of ionizing radiation (USA patent 3001880) [1]. The main reason for the change in the optical property of glass under radiant excitation of electrons is the coloration in the visible range of the spectrum which disappears with time.

The chemical resistance of glass to radiation coloration depends both on its composition and impurity inclusions. It was found that “damping” of an optical fiber [2] resulting from radiation and depending on the dose received is related to fixation of electrons in impurities, causing spectral absorption. Therefore is it advisable to make glass fibers out of high-purity material.

Boron-containing glass is especially sensitive to physical perturbations under thermal neutron radiation because of the reaction $B^{10}(n, \alpha)Li^7$, in the course of which α -particles are released (helium accumulates). Glass containing 28% B_2O_3 breaks completely under integral neutron heat flow at 2.5×10^{16} neutron/cm², glass with 16% B_2O_3 proved resistant with radiation at 1.2×10^{17} neutron/cm² (not more than 1×10^{20} neutron/cm²).

The addition of cerium dioxide reduces the susceptibility of the glass to the effect of the neutrons, and in this case the glass acquires a yellowish tint. Nergaard suggested earlier that impurities acting as donor sources form vacant nodes of oxygen ions, resulting, in the case of their excess, in the appearance of *F*-centers.

As the result of gamma-radiation, the glass itself becomes a secondary source of radiation (after its illumination with ul-

traviolet light). The intensity of the luminescence is in direct proportion to the gamma-radiation dose, therefore glass can be used as the measuring unit of a dosimeter. Glass is sensitive to radiation from 5 to 1000 R.

Thus, ionizing radiation cannot only cause a new state in the glass but also affect the rate of the change of this state, as well as diffusion processes, which is very essential for the synthesis of glass, including technical glass.

In this context, the use of ionizing radiation in glass-making technology has both theoretical and practical significance.

Optical materials (glass, crystals, fiber-optical elements etc.) have to meet a series of rigid requirements, of which the basic ones are the homogeneity of the glass and its high mechanical strength. The only real method for improving the strength of glass and at the same time upgrading the homogeneity of optical materials is to change its structure, which depends on the peculiarities of its production technology.

In the course of glass-making, the difference between the mixture formula and the chemical composition of the glass has to be taken into account. It is known that this difference causes inevitable “fining” of the glass in the furnace and makes inevitable as well the presence of some degree of gas inclusions in the ionic structure of the glass. This is especially true for the components which in the course of glass-making undergo transformations that are described by a Langmuir curve. Radiation increases the capacity of the substances for easier decomposition (the induction period is reduced) and causes other reversible and irreversible changes depending on the specific conditions.

Under the effect of radiation treatment, a process of selective activation of atoms and molecules for the chemical reaction takes place; it can be likened to “preparation” of the atoms, which at a high temperature glide over the surface with a greater speed and align in such a way that the possibility arises for the last unfilled layer to continue growing.

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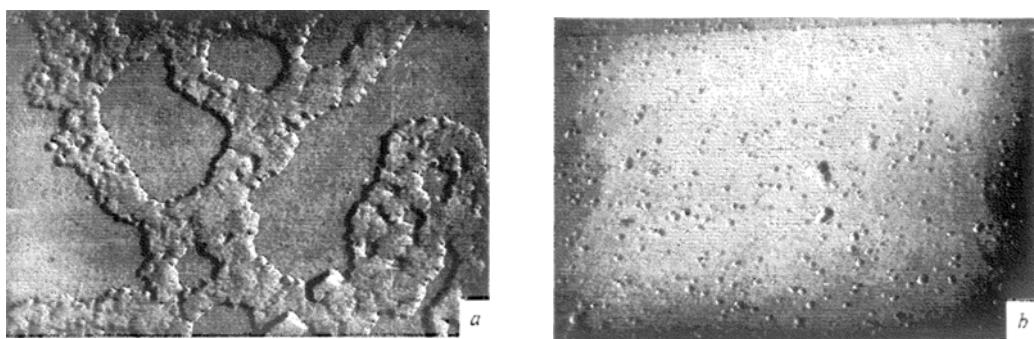


Fig 1. Microstructure of glass obtained by industrial (a) and radiation (b) technologies ($\times 300$).

Thus, the particles of the material mixture pass into the excited state, but since every material contains impurity atoms, the active atoms of the impurities also become excited. This has a positive influence on the glass-making process (the excited particles spontaneously go over to a lower metastable level).

Accordingly, in the course of synthesis of glass by the chemical radiation method, an excited atom is capable, first, of radiating spontaneously the excitation energy, second, of transferring the energy entirely to the neighboring impurity atom if it is not excited and, third, transmitting to the neighboring atom only part of its energy. In this case, two new particles emerge with an excitation energy lower than that of the initial particle. Finally, two (or more) excited atoms can interact and combine their energy resources and have a positive influence on the process of silicate and glass formation.

Considering the chemical radiation technology of glass-making, it is necessary to analyze the behavior not only of the individual particles but of all melted particles that integrate a unified energy system.

It was established experimentally that impurity atoms play a fundamental role in activation of the glass-making process. Their life span in the excited state depends greatly on the neighboring atoms, which may act as accumulators of the excited atoms. By controlling the concentration of active particles, one can deliberately direct the glass-making process.

The study of microinhomogeneity has shown that glass made according to the traditional industrial technology has

significant structural inhomogeneity. Chemical radiation treatment facilitates obtaining the most homogeneous glass (see Fig. 1), and the sizes of inhomogeneity areas range from 200 to 500 Å.

The use of the proposed technology accelerated the process of silicate-formation and glass-making and made it possible to obtain highly homogeneous, strong and chemically resistant (hydrophobic) glass products.

As a result of hydrophobization, the period of storage for the glass products becomes longer, the leakage of current in electronic lamps is reduced, and the reliability of fiber-optics systems is improved due to their improved illumination engineering parameters.

Thus, radiation treatment in the final stage of the complicated technological cycle of glass-making increases the reactive capacity of the batch grains, accelerates reactions of decarbonization and dehydratation, and has a positive effect on the homogeneity and illumination engineering parameters of the glass.

REFERENCES

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